A TRUSS STRUCTURE, STRUCTURAL MEMBERS THEREOF, AND A METHOD OF MANUFACTURE THEREFOR

BACKGROUND OF THE INVENTION

The present invention relates to a truss structure for use in a roofing and the like of a building.

As a space truss structure which can shorten the term for completion of work by facilitating the connection of its chord members, a conventional truss structure is disclosed in JPA Laid-Open No. 60-89744, in which a connection member is provided on one surface of which a connection tube for connecting chord members is erected, and on the other surface of which a rib for connecting diagonal chord members is mounted, whereby chord members each having a connecting part on the end thereof are connected thereto via washers which may be in any numbers. Further, JPA Laid-Open No. 5-311765 discloses a flat metal square column pipe member having a concave cross-section fitting member on both ends thereof formed by press or roll working, and wherein said concave cross-section fitting part is provided with a long narrow opening for fitting which is pierced therethrough. Still further, a double pipe type truss beam which integrates an upper chord member and a lower chord member formed of a pipe, and a web member is disclosed in JPA Laid-Open No. 7-180217. Still more, JPA Laid-Open No. 61-100704 discloses a connection structure for a truss joint which is comprised of joining diagonal pipe members via a cross gausset

plate to an M-shaped, H-shaped chord members or to a vertical pipe member, wherein a backup member outside the truss plane of the gausset plate is omitted such that the bore of the pipe between a flange and a web of the chord member is effectively utilized.

As mentioned above, various efforts have been made in order to facilitate the connection of the chord members and shorten the term for completion of work. Also, it is known to flatten the connection edge of the chord member by compression pressing to this effect. In this conventional structure, however, existence of a free plastic deformation part, which is elliptic and extends between the flat surface provided by compression pressing and the complete round section of a parent pipe member cannot be avoided. This long and narrow free plastic deformation part adjoining the connection end structure flattened by compression according to the conventional method is not only unnecessary but also disadvantageous in the truss structure because the size of the parent plate for connecting the chord member using a bolt thereto becomes inevitably large. Provision of such a large sized parent plate has been a cause to increase the size of its joint structure, thereby decreasing its rigidity, and increasing the cost of manufacture.

SUMMARY OF THE INVENTION

An object of the present invention is to provide for a truss structure which can improve its rigidity by reducing the

size of its joint structure, and improve the cost of manufacture by reducing the size of its parent member plate.

Another object of the invention is to provide for structural members suitable for use in constructing this truss structure, and a method of manufacture thereof.

One of the features of the present invention resides in that an edge portion of a pipe is forcibly pressed between an upper die and a lower die each having a same cylindrical surface of constraint. By use of such dies, it becomes possible to directly form a flat surface section on the edge of a pipe member while securing a complete round portion thereof serving as a complete round parent member. Therefore, the long free plastic deformation part which is inevitably formed using the conventional dies having a flat surface portion for forming a flat structure according to the conventional art can be eliminated, and a connection edge having a flat surface which is directly connected to the complete round parent member can be realized according to the invention. The present invention, as stated above, is characterized by the forced constrained pattern pressing of the edge portion of the pipe using the upper and the lower dies having a cylindrical semi-surface of constraint. However, it is not limited thereto, and a modification of which for providing a polygonal or a short elliptical structures instead of the cylindrical one should be construed within the scope of the invention. Essentially, in forming the flat section, it is intended to form a constrained

tubular portion between the flat section and the complete round parent member by a constrained pattern forming press, and the shape of this constrained tubular portion may be the same as the pipe as the complete round parent material or any shape required in its design.

More specifically, the truss structure, structural members therefor and the method of manufacture thereof as will be described below are provided according to the invention.

The present invention provides for the truss structure for connecting an upper chord member, lower chord member and diagonal chord member to its parent plate via respective connection parts of each member provided on both ends thereof, wherein the upper chord member, the lower chord member and the diagonal chord member used is a pipe member, and wherein the connection part of the pipe member is comprised of a tubular portion forcibly shaped into the same diameter and the flat surface portion formed integral with the tubular portion by compression pressing, further wherein the connection part is connected to the parent plate via a bolt opening provided in the flat surface portion.

Preferably, the connection part member includes the parent plate and a rib member erected cross-wise thereon, and each edge portion of each flat surface part is tapered and arranged in juxtaposition.

In the truss structure according to the invention having the upper chord member, the lower chord member and the diagonal

chord member each having the connection part on the both ends thereof for connecting to the parent plate therethrough, wherein the upper, the lower and the diagonal chord members use a pipe member, and the connection part has a flat surface portion formed by the compression pressing, with the edge portion of the flat surface portion being tapered, and wherein assuming a distance (2 x l) between connection center positions of two flat portions of juxtaposed two chord members to be "l" when divided by 2, and a diameter of a bolt opening provided in the flat surface portion to be "d", there holds a relationship between "l" and "d" as follows.

$l \leqq \sqrt{2}t/2+10\sqrt{2}+2.0\ d+B/2$, and $l>3d$ (in mm).

According to one aspect of the invention, the truss structural members are provided which include the upper chord, the lower chord and the diagonal chord members each having a connection part on the both ends thereof, wherein said connection part is comprised of the tubular portion forcibly formed into the constrained pattern with a constrained restriction, and the flat surface portion formed integral with the tubular portion by flat pressing, and wherein the bolt opening is provided in the flat surface portion.

According to another aspect of the invention, the die is provided for forming the connection part on the edge portion of the truss structural members such as the upper chord, the lower chord and the diagonal chord members, which are tubular, wherein the die is comprised of an upper press die and a lower

press die, each die having a half tubular curved surface open to the outside and placed oppositely to provide for a constraint groove in combination whereby to be able to form a constrained pattern.

According to still another aspect of the invention, the method for manufacturing the truss structural members such as the upper, the lower and the diagonal chord members which are provided with respective connection parts on both ends thereof is provided, wherein the same comprises the steps of: placing a pipe between the upper and the lower press dies each having the half tubular curved surface which is open to the external and positioned oppositely so as to provide for in combination one constrained shape; and forming simultaneously the flat surface portion connected integral with the tubular portion by pressing.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

Fig. 1 is a schematic plan view of a truss structure embodying the invention;

Fig. 2 is a cross-sectional view of Fig. 1;

Fig. 3 is a plan view of a joint according to one embodiment of the invention;

Fig. 4 is a cross-sectional side view of Fig. 3;

Fig. 5 is a perspective view indicating a method of manufacture according to the invention;

Figs. 6 (a), (b) show two different embodiments of the invention;

Figs. 7(a), (b) show still other embodiments of the invention; and

Figs. 8 (a), (b) show examples of joint structures using the embodiments of Figs. 6 (a), (b).

PREFERRBED EMBODIMENTS

With reference to Figs. 1 and 2, a plan view and a cross-section of a truss structure according to the invention are shown. In these drawings, numeral 1 depicts a lower chord member, 2 depicts an upper chord member, 3 depicts a diagonal chord member, and 4 depicts a cross plate, respectively. This truss structure which is formed by lower chord member 1, upper chord member 2 and diagonal chord member has a rectangular cross-section extending in a span direction and a column direction. The lower chord member 1, the upper chord member 2 and the diagonal chord member 3 are jointed to the cross plate 4 with bolts for assembly. The cross plate 4 is formed by welding a plate for the chord member and a plate for the diagonal chord member in crosswise.

Now, with reference to Figs. 3 and 4, a connection part 10 of the chord member is comprised of a flat surface section 11 and a constrained complete round pipe section 12. The

constrained complete round pipe section 12 as will be described later is a constrained complete round portion formed by compression between the upper and the lower press dies, and having a structure directly connected to the flat surface portion 11. However, because there naturally exists a transitional deformation portion from the complete round portion to the flat surface portion, it should be understood that a curved surface portion 13 having a small radius of curvature must be formed therebetween. This curved surface is also constrain-formed and has a semi-circle. The leading edge of the flat surface portion is formed into a tapered shape 14. A plurality of bolt holes 17 are formed along a line connecting between the tapered leading edge portion and the center of the constrained complete round pipe portion 12 (two bolt holes are provided in the case of Fig. 3). The connection part 10 of the chord member has the flat surface portion 11 formed by the compression pressing as will be described more in detail later, and bolt holes 17 are formed into this flat surface portion 11, and the leading edge of the flat surface portion 11 is tapered into a pointed shape 14. This connection part 10 is firmly connected with bolts 18 to parent plates 15 and 16 which are assembled cross-wisely by welding. The method of manufacture thereof will be described with reference to Fig. 5.

The die is comprised of the upper die press 21 and the lower die press 22, and in each die press, there are formed a flat surface press section 23, a semi-circular cylindrical

surface press section 24 and a curved surface press section 25. A pipe chord member 1, 2, 3 is placed in the semi-circular cylindrical surface press section 24 between the upper and the lower die press 21, 22, and forcibly pressed. By provision of such arrangements, a connection part 10 having the structure as shown in Fig. 5 (c) can be obtained wherein the constrained complete round pipe portion 12 and the flat surface portion are directly connected via the curved surface portion 13. The edge portion of the connection part 10 may be prefabricated then pressed, or may be fabricated after presswork.

With reference to Fig. 5 (c), there is formed a transitional slack portion 11′ on the edge portion of the pipe 12 flattening from the complete round constrained tube. This flattening slack portion 11′ "a" which extends from the pipe 12 to the flat surface part 11 has an important function to transmit a stress from the section 11 to the section 12. The conventional connection part of an elliptical shape formed using the conventional flat press does not have this portion "a" according to the invention.

An advantage realized by provision of the tapered leading edge at the connection part 10 will be described in the following. Figs. 6 (a) and (b) show two examples of the invention, in which (a) indicates one without tapering, and (b) indicates one with a tapered leading edge. In the case of (b), an angle of its leading edge tapering corresponds to an angle of a parent plate 16 which is mounted crosswise. Here, let's assume that a

diameter of a bolt is "d", and a distance between the center of the diameter of a forefront bolt and the center of joint of the crosswise parent plate is "L" in the case of (a), and "l" in the case of (b). Namely, "L" or "l" represents a half-length of a distance between counterposed joints. Further, symbol "B" and "t" depict a width of a flattened pipe or chord member plate, and a thickness of the parent plate for use of the diagonal chord members, respectively.

Figs. 7 (a) and (b) show other embodiments of tapered flat plate sections of the invention. Fig. 7 (a) is an example having rounded corners, and Fig. 7 (b) is an example which is tapered into a sword edge.

Examples of truss structures assembled using the embodiments of Figs. 7 (a) and (b) are shown in Fig. 8. Numeral 150 depicts a plate for diagonal chord members. As clearly understood from the drawing, by provision of a tapered sword edge to the flattened plate section of the pipe, a distance from the center of joint to the center of the bolt can be shortened substantially. It is easily understood as well that the sizes of parent plates 15 and 16 can be reduced. It should be noted here that by adoption of "l" which is shorter than "L", the mechanical stability and endurance of the joint can be increased substantially. Further, the cost of manufacture thereof can be reduced. In the case of the embodiment of Fig. 6 (b), a relationship between "l" and "d" is defined to be $l/d \fallingdotseq 4$, however, it is not limited thereto, and the following equations may be

adopted depending on the types of bolts to be used.

In the case of Fig. 6 (b):

$1 \leqq \sqrt{2t/2+10\sqrt{2+2.5d}}$ (mm) (eq. 1)

In the case of Figs. 7(a) and (b):

$1 \leqq \sqrt{2t/2+10\sqrt{2+2.0d}} + B/2$ (mm) (eq. 2), and

$1>3d$ (eq.3).

In the case of Fig. 6 (a):

$\sqrt{2t/2+10\sqrt{2+2.5d}}$ (mm) $< L \leqq \sqrt{2t/2+10\sqrt{2+2.5d}} + B/2$ (mm) (eq. 4).

With the diameter of the bolt assumed to be "d", and the leading edge to be tapered, any length of "l" can be determined according to the above-mentioned equations. Therefore, the distance between two separate joints can be shortened substantially thereby improving the rigidity of the joints compared to those of the embodiment of Fig. 6 (a). Some examples according to the invention are shown in Table 1.

TABLE 1 : EXAMPLES OF QUANTITIES

(B=63.4, in mm.)

when t=6:

d	Fig.6 (a)	Figs.7 (a)&(b)	Fig.6(a)
12	48.4	74.1	80.1
16	58.4	82.1	90.1
20	68.4	90.1	100.1
22	73.4	94.1	105.1
24	78.4	98.1	110.1

when t=9:

d	Fig.6(a)	Figs.7 (a)&(b)	Fig.6(a)
12	50.5	76.2	82.2
16	60.5	84.2	92.2
20	70.5	92.2	102.2
22	75.5	96.2	107.2
24	80.5	100.2	112.2

Further, even in the cases of examples of Fig. 6 (a) of the invention, because the plastic deformation portions inevitably present in the conventional products are eliminated, inter-distance between the joints can be shortened, thereby increasing the rigidity of the joints accordingly.

As described heretofore, because the pipe member serving as the chord member is provided with the constrained curved surface section and flattened tube section on both ends thereof which are formed by the constrained pattern shaping pressing in order to facilitate the connection and assembly thereof, the design limitation involved in the prior art that the size of the parent plates becomes inevitably large due to the existence of the free plastic deformation portion therein can be eliminated. Therefore, the size of the parent plates can be decreased substantially, thereby increasing the rigidity of the joints.

Further, by provision of the tapered leading edge to the flattened connection part of the chord members, the inter-joint distance can be reduced substantially, thereby increasing the rigidity of the joint.